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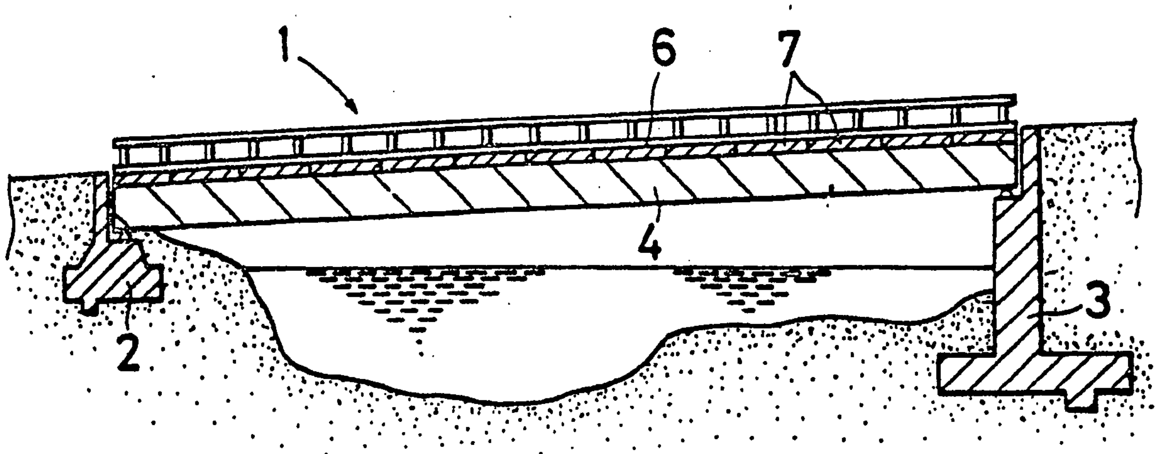
(54) **A method for forming a composite structural member.**

(57) A method for forming a composite structural member (1) wherein a prestressed concrete floor board(7) having compressive stress acting along pc steel wires(8) buried therein is fixedly mounted on a steel beam(4), and the compressive stress is thereafter released from the prestressed concrete floor board(7) by loosening a turnbuckle(9) or the like provided in the prestressed concrete floor board(7) so as to produce in the steel beam(4) tensile force acting in the same direction as the direction of the compressive stress acting in the prestressed concrete floor board(7) and bending moment.

Fig. 1



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A METHOD FOR FORMING A COMPOSITE STRUCTURAL MEMBER

This invention generally relates to a method for forming a composite structural member using prestressed concrete members, and more particularly to a method which may be preferably applied to the forming of composite beams by, for example, combining reinforced concrete floor boards and steel beams in a composite beam bridge. As one of conventional examples of composite structural members widely used, composite beams or girders are pointed out which are composed of reinforced concrete floor boards and steel beams in a composite beam bridge. Such composite beams are arranged in such a way that a reinforced concrete floor board and a steel beam are made integral by using a connector such as dowel whereby both the members can resist, in cooperation with each other, the load to be applied thereafter. In this conventional method, in order to install reinforced concrete floor boards, first the steel beams are erected, and forms are prepared, then concrete is placed, which, therefore, requires a huge manpower for installation of forms and floor boards with high costs. Besides, in this composite beam bridge, the steel beam area is subjected to a positive bending moment due to vertical loads such as the own weight of steel beams, dead loads of floor boards, earth covering, balustrade, and pavement, and live loads of pedestrians and vehicles. As a result, a compressive stress is generated at the upper edge side of steel beams, while a tensile stress is generated at the lower edge side. These stresses lead to damages or failures such as cracks in the composite beam bridge. In order to prevent such damages or failures, the cross section of steel beams is designed with a proper appowance for said vertical load. Accordingly, the sectional area of steel beam becomes comparatively wide, and therefore the weight of steel beam increases, so that the entire size of the composite beam becomes larger. This means an additional cost to the construction of a bridge.

Therefore, to solve the aforesaid technical problems, it is an object of the invention to provide a method for forming a composite structural member which can reduce the size and weight of the composite structural member and decrease the manufacturing cost consumed.

It is another object of the invention to provide a method fqr forming a composite structural member utilizing a prestressed concrete member which, when applied to a composite beam bridge, can accomplish the decrease of manpower and cost required to manufacture the reinforced concrete floor boards and the reduction of the steel beam in size and weight, thus effecting the economical composite beam bridge.

A method for forming a composite structural member in accordance with the invention comprises the steps of ① preparing preliminarily an auxiliary member so arranged that there are compressive stress generating means and compressive stress releasing means and compressive stress is acting in one direction on the inside of the auxiliary member by means of the compressive stress generating means, preparing a foundation member, disposing fixedly the auxiliary member on the foundation member in such a way that the direction of the compressive stress acting and the axial direction of the foundation member are parallel with each other, and causing thereafter the compressive stress releasing means to release the compressive stress from the auxiliary member so as to generate in the foundation member tensile force acting in the same direction as the direction of the compressive stress acting and bending moment.

In a preferred emodiment, the first step comprises burying a plurality of pc steel wires in the auxiliary member in a straight line, forming in the auxiliary member a slot communicating with the outside, disposing in the slot a turnbuckle for connecting the pc steel wires with each other such that pc steel wires pass through the auxiliary member, and applying to the pc steel wires a tension acting away from the turnbuckle so as to produce the compressive stress acting along the axial direction of the pc steel wires inside the auxiliary member, and the last step comprises loosening the turnbuckle so as to release the compressive stress from the auxiliary member.

In another preferred embodiment, the first step comprises burying a sheath tube in the auxiliary member such that the sheath tube passes through the auxiliary member, passing the pc steel wire through the sheath tube, applying to the pc steel wire a tension for energizing both ends thereof away from each other, and fixing and maintaining the pc steel wire having both the ends thereof thus energized away from each other by means of fixing means, and the last step comprises loosening the fixing means to a desired degree so as to release the compressive stress corresponding to the desired degree from the auxiliary member.

Furthermore, in still another preferred embodiment, the third step comprises placing a plurality of foundation members at specified intervals, disposing across the foundation members a plurality of auxiliary members each having undulated surfaces formed at both ends thereof in the direction parallel with the direction of the compressive stress acting in such a way that the undulated surfaces at the ends of the auxiliary members confront each other on the foundation members, and filling spaces between the

undulated surfaces confronting each other with a bonding agent whereby the auxiliary members are fixedly disposed on the foundation members.

Besides, in yet another preferred embodiment, concrete member is utilized for the auxiliary member and a steel member is utilized for the foundation member.

Moreover, preferably the concrete member is a precast concrete board and the steel member is a steel beam.

Consequently, in accordance with the invention, when the composite structural member is formed, it is given force acting in the direction reverse to the direction of the compressive force generated by the load and the bending moment to be considered into designing and on being relieved of the compressive stress already present inside the composite structure member, thereby achieving the reduction of the member in size and weight.

These and other objects, features and advantages of the invention will become more apparent upon a reading of the following detailed specification and drawings, in which:

Fig. 1 is a side elevation of an embodiment of a bridge in accordance with the invention;

Fig. 2 is a plan view of Fig. 1;

Fig. 3 is a plan view showing a prestressed concrete floor board of the invention;

Fig. 4 is a cross section taken along the line IV-IV of Fig.3;

Fig. 5 is a diagram explaining processes for forming the prestressed concrete floor board of the invention;

Fig. 6 is a simplified perspective view showing part of the state of the prestressed concrete floor board mounted on a steel beam of the invention;

Fig. 7 is a front view seen from the arrow A side of Fig.6;

Fig. 8 is a plan view of the prestressed concrete floor board of another embodiment of the invention;

Fig. 9 is a cross section taken along the line IX-IX of Fig. 8;

Figs. 10(1) through 10(3) are diagrams explaining the intensity of stress acting on the steel beam and the concrete floor board of the invention;

Figs. 11(1) through 11(4) are bending moment diagrams corresponding to Figs. 10(1) through 10(3);

Fig. 12 is a diagram presenting a foundation for analyzing practically the intensity of stress acting on the prestressed concrete floor boards and the steel beam after releasing of prestress;

Fig. 13 is a simplified perspective view showing part of the state of the prestressed concrete floor boards mounted on the steel beam of another embodiment of the invention;

Fig. 14 is a plan view seen from the arrow F side of Fig. 13;

Fig. 15 is a cross section taken along the line XV-XV of Fig. 14;

Fig. 16 is a plan view showing the prestressed concrete floor boards of still another embodiment of the invention;

Fig. 17 is an enlarged perspective view showing part of Fig. 16.

Fig. 1 is a side elevation of one of the embodiments of a bridge built in accordance with this invention, and Fig. 2 is a plan view of Fig. 1. A bridge 1 is supported by abutments 2 and 3 at both ends thereof. The bridge 1 possesses a framework comprising a plurality of steel beams 4 as the foundation members composed of I-section main beams extending in the axial direction of the bridge 1, and steel members 5 called horizontal beams or opposite inclined structures which are supported by these main beams. A passage way board 6 is placed on the steel beams 4. In Fig. 2, the right half of this passage way board 6 is omitted for readily understanding the illustration. This passage way board 6 is constituted by a plurality of floor boards 7 joined with one another and acting as auxiliary members. In the concrete floor boards 7, as will be mentioned below, a plurality of pc steel wires (high tension steel wires) 8 (see Fig. 3) extending in the width wise direction are buried in parallel with one another. The concrete floor boards 7 are so arranged that the pc steel wires 8 built therein may be parallel to the steel beams 4. Additionally, instead of pc steel wires 8, pc steel bars may be used for the same purpose.

Fig. 3 is a plan view of prestressed concrete floor board 7 in accordance with this invention, and Fig. 4 is a cross section taken along the line IV-IV in Fig. 3. In the concrete floor boards 7, pc steel wires 8 are buried, being extended in the widthwise direction (the transverse direction in Fig. 3), through turnbuckles 9. In these concrete floor boards 7, too, slots 10 are formed, being opened upward and enclosing these turnbuckles 9. The internal compressive stress of the concrete floor boards 7 is released by operating the turnbuckles in the slots 10 from outside. Instead of the turnbuckles, couplers of which threads are formed inside along the axial direction may be used. Or the pc steel wires 8 may not be necessarily linked by way of turnbuckles 9 or couplers, and in such a case, the internal compressive force may be released by cutting the pc steel wires 8 in the slots 10. Additionally, slots 15 are provided to be filled with high strength mortar or the like in order to make the steel beams 4 and the concrete floor boards 7 integral.

Such concrete floor boards 7 are prefabricated at shop in the following procedure. As shown in Fig. 5, a mould form 16a is set as indicated by an imaginary line, and a form 16b for slots 10, 15 may be set if necessary. In this form 16a, unbonded pc steel wires 8 which do not adhere to concrete are arranged together with necessary reinforcing bars, and concrete is poured in. After curing for a specified period, a proper tension is applied to the pc steel wires 8 by means of a jack or the like to fix by means of support pressure boards 11 and 12, and fixing members 13 and 14. At this time, a compressive force acts on the concrete with the help of the support pressure boards 11 and 12, and a compressive stress is generated inside. Thus, concrete floor boards 7 in which a compressive stress is already present can be fabricated.

Fig. 6 is a simplified perspective view showing part of the state of a concrete floor board 7 mounted on the steel beam 4 and Fig. 7 is a front view seen from the arrow A side of Fig. 6. The steel beam 4 extending in the horizontal direction comprises a web 20 extending in the vertical direction, and upper flange 21 and lower flange 22 extending in a direction perpendicular to the web 20 at both ends of the web 20. An antiskid member 23 for preventing the concrete floor board 7 from slipping is attached to the upper surface of the upper flange 21. This antiskid member 23 is, for example, a dowel which is composed of a plurality of bar-shaped projections 24 welded on the upper surface of the upper flange 21. A plurality of antiskid members 23 are disposed on the upper surface of the upper flange 21 at interals.

On such steel beams 4, a plurality of concrete floor boards 7 are so placed, side by side, that the pc steel wires 8 and main beam 4 may be parallel to each other. For fixing the steel beam 4 and concrete floor boards 7 integrally, protrusions 24 of the antiskid members 23 are inserted into the slots 15 preliminarily provided at predetermined positions of the stopping part 7a called the hunch projecting downward of the concrete floor boards 7, and then the slots 15 are filled up with high strength mortar to fix the concrete floor boards 7 and the main beam 7 rigidly and integrally.

Then by loosening the turnbuckles 9 or the fixing part 13 or 14, the tension of the pc steel wires 8 is released. As a result, the concrete floor boards 7 having been compressed by a prestress (the existing compressive force) tend to stretch in the widthwise direction. However, since the concrete floor boards 7 and the steel beam 4 are integrally formed, their elongation is restricted, so that the negative moment to warping the beam upward and the tensile force act on the main steel 4. Therefore, the composite beam in accordance with the invention has smaller positive bending moment by this negative bending moment than the ordinary composite beam composed of unprestressed concrete floor boards disposed on the main beam. Hence, if a positive bending moment due to live load of vehicles and pedestrians and the like is applied, there is a sufficient allowance to the limit of allowable bending stress, so that the sectional area of steel beam may be even reduced.

Furthermore, since these concrete floor boards 7 are prefabricated at shop, and passage way boards 6 are erected in the field by using them, it is more economical as compared with the conventional method of forming passage way boards by setting up forms in the field and pouring concrete into the forms because the forms are unnecessary. Or in designing of a bridge, it is not necessary to take into consideration the load of forms, so that the sectional area of the steel beam 4 may be reduced for that.

Fig. 8 is a plan view of the prestressed concrete floor board 7 of another embodiment, and Fig. 9 is a cross section taken along the line IX-IX of Fig. 8. In this embodiment, like numerals are attached to the parts corresponding to those used in the embodiment shown in Fig. 3. What is noticed in this embodiment is that turnbuckles 9 are not used. Therefore, slots 10 in the embodiment in Fig. 3 are not formed either. To release the internal compressive stress from such prestressed concrete floor boards 7, the fixing members 13 and 14 of the pc steel wires 8 are loosened by jack operation or the like. Additionally, slots 15 are provided for the purpose of accomplishing the same effect as in the embodiment disclosed in Fig. 3.

Fig. 10 explains the intensity of stress acting on the steel beam 4 and concrete floor board 7 when the concrete floor boards shown in Fig. 3 and Fig. 8 are installed in the steel beam 4, while Fig. 11 shows the bending moment diagrams corresponding to Fig. 10. In Fig. 10, for the convenience of simplified explanation, it is assumed that the steel beam 4 is supported by simple fulcrums 26 and 27 at both ends thereof. The state of the steel beam 4 being supported by fulcrums 26 and 27 is illustrated in diagram (1) of Fig. 10. In this state, the steel beam 4 is subjected to a positive bending moment ℓ1 expressed by a parabola in a diagram (1) of Fig. 11 due to the equally distributed load by own weight. when concrete floor boards 7 are put on the steel beam 4 and formed integrally, the state is shown in a diagram (2) of Fig. 10, in which the bending moment ℓ2 is shown in the diagram (2) of Fig. 11. When the prestress present inside the concrete floor boards 7 is released, the tensile force p of the concrete to return to the initial shape acts on the steel beam 4 as shown in a diagram (3) of Fig. 10, and, as a result, a negative bending moment ℓ3 acts on the steel beam 4. To be precise, the negative bending moment ℓ3 due to prestress shown in the diagram (3) of Fig. 11 is added to the bending moment in the diagram (2) of Fig. 11, so that a bending moment ℓ4 as shown in diagram (4) of Fig. 11 acts on the steel beam 4. In a diagram (4) of Fig. 11, the

actual bending moment is smaller than the bending moment of an ordinary composite beam expressed by an imaginary line ℓ5 by the bending moment ℓ3 due to prestress. Thus, when compared with the ordinary composite beam, the positive bending moment may be decreased cin this invention, so that the section of steel beam 4 may be made smaller.

Fig. 12 is a diagram presenting a foundation for analyzing practically the intensity of stress acting on the concrete floor boards 7 and steel beam 4 after releasing of prestress. Sectional forces acting on the composite section,that is, the stress in the axial direction N and the bending moment M are expressed in Eqs. 1 and 2.

$N = -pc$ (1)

$M = N \cdot dc = -pc \cdot dc$ (2)

where pc represents prestress, and dc represents the distance between center of gravity c of the section of concrete floor board and the center of gravity v of composite section.

The edge stresses δsu and δsℓ of the steel beam 4 are expressed in Eq. 3.

$$\left.\begin{aligned} \delta su &= \frac{N}{Av} - \frac{M}{Iv}\, yvsu \\ \delta s\ell &= \frac{N}{Av} - \frac{M}{Iv}\, yvs\ell \end{aligned}\right\} \quad \ldots (3)$$

where Av is the sectional area of composite section, Iv is the second moment of area of the composite section, yvsu is the distance between the center of gravity of composite section and upper flange, and yvsℓ is the distance between the center of gravity of composite section and lower flange.

Putting Eqs. 1 and 2 into Eq. 3, the edge stresses δsu and δsℓ may be expressed in Eq. 4.

$$\left.\begin{aligned} \delta su &= \frac{-pc}{Av} + \frac{pc \cdot dc}{Iv}\, yvsu \\ \delta s\ell &= -\frac{-pc}{Av} + \frac{pc \cdot dc}{Iv}\, yvs\ell \end{aligned}\right\} \quad \ldots (4)$$

The edge stresses δcu and δcℓ of concrete floor board 7 are expressed in Eqs. 5 and 6, respectively, since the compressive force of presstress pc/concrete floor board sectional area Ac is initially present.

$$\begin{aligned} \delta cu &= \frac{pc}{Ac} + \frac{N}{n \cdot Av} - \frac{M}{n \cdot Iv}\, yvcu \\ &= \frac{pc}{Ac} - \frac{pc}{n \cdot Av} + \frac{pc \cdot dc}{n \cdot Iv}\, yvcu \end{aligned} \quad \ldots (5)$$

$$\begin{aligned} \delta c\ell &= \frac{pc}{Ac} + \frac{N}{n \cdot Av} - \frac{M}{n \cdot Iv}\, yvc\ell \\ &= \frac{pc}{Ac} - \frac{pc}{n \cdot Av} + \frac{pc \cdot dc}{n \cdot Iv}\, yvc\ell \end{aligned} \quad \ldots (6)$$

where n is the ratio of elasticity modulus Ec of concrete to elasticity modulus of main beam, that is, n = Es/Ec, yvcu is the distance between the center of gravity v of composite section and the upper surface of concrete floor board 7, and yvcℓ is the distance between the center of gravity v of composite section and the upper flange.

When erecting a road bridge with simple live load composite beams by using forms, the loads to be considered before forming a composite structure are generally shown in TABLE 1.

TABLE 1

Steel weight	0.150 t/m² ~ 0.250 t/m²
Floor boards	0.400 t/m² ~ 0.600 t/m²
Hunches	0.050 t/m² ~ 0.100 t/m²
Forms	0.100 t/m²

Accordingly, the load to be considered in ordinary composite beams is 0.700 t/m² to 1.050 t/m², while the load to be considered in this invention without using forms is 0.600 t/m² to 0.950 t/m². Therefore, the dead load during installation of floor boards may be reduced by 14 to 10%. Furthermore, based upon the aforementioned results and Eqs. 4 to 6, the inventor calculated the design relating to the ordinary composite beams and the composite beams according to this invention, and obtained the results as partly shown in TABLE 2. In this table, the allowable stress is assumed to be ±2100 kg/cm², and the concrete section, 2736 cm by 230 cm.

TABLE 2

	Ordinary composite beam	Composite beam by this invention
Upper flange sectional area (cm²)	420 × 21 = 90.3	380 × 19 = 72.2
Web sectional area	2000 × 10 = 200	2000 × 9 = 180
Lower flange sectional area	590 × 35 = 206.5	610 × 30 = 183
Total surface area	494.7	435.2

According to TABLE 2, the weight ratio of main beam may be expressed as shown in Eq. 7.

$$\frac{388.2 - 341.6}{388.3} \times 100 = 12.0\% \qquad \ldots (7)$$

That is, in accordance with the invention, the weight of the main beam may be reduced by 12.0% from that of the conventional beam.

Usually, the steel beam of composite beam bridge is subjected to the positive bending moment due to vertical loads of dead load and live loads of own weight of steel beam, floor board, soil covering, balustrade, pavement, etc., and a compressive stress acts on the upper edge side and a tensile stress is present on the lower edge side. In this method, since a tensile force and a negative bending moment act on the steel beam part by releasing stress from the concrete floor boards after integrally forming precast prestressed concrete floor boards having an internal compressive stress and the steel beams, both the compressive stress on the upper edge side and the tensile stress on the lower edge side are reduced as compared with those in the conventional method. Therefore, the method in accordance with the invention enables the composite beam bridge to resist a greater load than that in accordance with the conventional method. That is, when the two are compared in the case of same vertical load being applied to them, the required sectional area of the steel beam in this method is smaller, thereby reducing the steel beam in size and weight. Furthermore, by decreasing the sectional area of steel beam, the beam height can be lowered, so that the load of wind pressure or other factors applied on the side of the bridge may be decreased. Besides, this may be applied in a location where the space beneath the beam is limited, and by diminishing the height of the road erection, it is also economically advantageous.

In the conventional method, meanwhile, it is necessary to set up forms for installing reinforced concrete floor boards, but forms are not necessary in this method because precast floor boards are used which are prefabricated at shop or the like, and the manpower and cost for installation of floor boards may be saved.

Moreover, in the case where the present invention is applied to composite structural members in which a compressive force is present, a tensile force acts on foundation members when a stress is released form

a precast prestressed concrete members having an internal compressive stress and made integral with the foundation members on which the compressive force that is generated by a load to be considered into designing of the members acts. In consequence the compressive force thus generated by the load is cancelled. That is, as in the case of application to composite beam bridge, by omission of form setup, the manpower and cost may be saved and the members may be reduced in weight and size, so that economical composite structural members may be obtained.

Fig. 13 is a simplified perspective view showing part of the state of concrete floor boards, 7a mounted on the steel beam 4 in still another embodiment of the invention, Fig. 14 is a plan view seen from the arrow F side of Fig. 13, and Fig. 15 is a cross section taken along the line XV-XV of Fig. 14. This embodiment is similar to the preceding ones, and like numerals are given to the corresponding parts. What is of note here is that a plurality of sheath tubes 50 are in advance penetrated through the concrete floor board 7a in the bridge axial direction W. The diameter of the sheath tubes 50 is so selected that pc steel wires 8 may loosely pass thereinto.

The process of forming a passage way board 6 by mounting the concrete floor board 7a on the steel beam 4 will be explained below.

In the first step, concrete floor boards are provisionally mounted on the steel beam 4 without gap. Then adhesive or cement mortar is applied to the seams 40 of the concrete floor boards 7 to make each concrete floor board 7a integral with one another. Next, a prestress is introduced into the concrete floor board 7a along the bridge axial direction W, and a compressive stress is applied to the concrete floor board 7a. To be precise, pc steel wires 8 are inserted into the sheath tubes 50, and then a tension is applied to the pc steel wires 8 by means of a jack or the like to fix firmly with support plates 51 and fixing members 52. At this time, a compressive force acts on the concrete with the help of the support plates 51, and a compressive stress is generated inside. The fixing members 52 provide means of fixing and securing the compressive stress to the concrete floor board 7a, and also have the function of freely adjusting the compressive stress in the concrete floor board 7a as mentioned below.

The concrete floor board 7a thus prestressed is formed integrally with the steel beam 4. Particularly, slots 15 in the concrete floor board 7a are filled up with concrete or cement mortar. As a result, the concrete floor board 7a and the steel beam 4 are mutually fixed and assembled into an integral form. Thus, the steel beam and concrete floor board 7a make up a composite beam. After thus combining the concrete floor board 7 and steel beam 4, by relieving the concrete floor board 7 of its prestress along the bridge axial direction W, a tensile force and a bending moment are created on the steel beam 4. Precisely, by loosening the fixing members 52, the tension of the pc steel wires 8 is released. As a result, the concrete floor board 7a having been compressed by the prestress (the compressive stress already generated) tends to stretch in the bridge axial direction W. However, since the concrete floor board 7a is integrally formed with the steel beam 4, its elongation is arrested, and consequently a negative moment and tensile force warping the beam upward act on the steel beam 4. Accordingly, the composite beam in accordance with the invention has the smaller positive moment by the bending moment than the ordinary composite beam composed of the unprestressed concrete boards disposed on the main beam. In consequence, if a positive bending moment due to live load of vehicles and pedestrians and the like is applied, there is a sufficient allowance to the limit of allowable bending stress, so that the sectional area of main beam may be reduced. After the relief of prestress, the sheath tubes 50 are grouted with cement paste or the like.

Furthermore, at the time of relief of prestress, by loosening the fixing members 52 only by a desired amount, the stress acting on the entire composite structural members can be adjusted as desired.

The concrete floor boards 7a are prefabricated at shop in the above embodiments, but it is evident that the same effect will be obtained by setting up forms in the field and pouring concrete in them as in the conventional field concrete placing method.

Fig. 16 is a plan view of the concrete floor board by yet another embodiment, and Fig. 17 is a perspective view magnifying part of Fig. 16. Concrete floor boards 7b have undulated surfaces 55 formed at its both ends in the transverse direction (the direction parallel with the bridge axial direction). In each of the undulated surfaces 55, a plurality of concave portions 56 are formed at specified intervals along the bridge axial direction W. If, for example, the width d3 of this concrete floor board 7b is taken as 1.5 m, the depth d1 of the concave portion 56 is 2 cm, and the pitch d2 is 20 cm. The shape of the undulated surface 5s 1.5 m, the depth d1 of the concave portion 56 is 2 cm, and the pitch d2 is 20 cm. The shape of the undulated surface 55 is not limited to that shown in Fig. 17, and as a matter of course, the depth d1 and d2 are not either limited. The concrete floor boards 7b in such shape are disposed, at specified intervals in confronting relation to each other, on the upper flange 10 of the steel beam 4. Thereafter, same as in the preceding embodiment, prestress is introduced, and the boards are fixed by the fixing members 52 after the generation of compressive stress. Then, when making the concrete floor boards 7b and the steel beam 4

a precast prestressed concrete members having an internal compressive stress and made integral with the foundation members on which the compressive force that is generated by a load to be considered into designing of the members acts. In consequence the compressive force thus generated by the load is cancelled. That is, as in the case of application to composite beam bridge, by omission of form setup, the manpower and cost may be saved and the members may be reduced in weight and size, so that economical composite structural members may be obtained.

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Furthermore, at the time of relief of prestress, by loosening the fixing members 52 only by a desired amount, the stress acting on the entire composite structural members can be adjusted as desired.

The concrete floor boards 7a are prefabricated at shop in the above embodiments, but it is evident that the same effect will be obtained by setting up forms in the field and pouring concrete in them as in the conventional field concrete placing method.

Fig. 16 is a plan view of the concrete floor board by yet another embodiment, and Fig. 17 is a perspective view magnifying part of Fig. 16. Concrete floor boards 7b have undulated surfaces 55 formed at its both ends in the transverse direction (the direction parallel with the bridge axial direction). In each of the undulated surfaces 55, a plurality of concave portions 56 are formed at specified intervals along the bridge axial direction W. If, for example, the width d3 of this concrete floor board 7b is taken as 1.5 m, the depth d1 of the concave portion 56 is 2 cm, and the pitch d2 is 20 cm. The shape of the undulated surface 5s 1.5 m, the depth d1 of the concave portion 56 is 2 cm, and the pitch d2 is 20 cm. The shape of the undulated surface 55 is not limited to that shown in Fig. 17, and as a matter of course, the depth d1 and d2 are not either limited. The concrete floor boards 7b in such shape are disposed, at specified intervals in confronting relation to each other, on the upper flange 10 of the steel beam 4. Thereafter, same as in the preceding embodiment, prestress is introduced, and the boards are fixed by the fixing members 52 after the generation of compressive stress. Then, when making the concrete floor boards 7b and the steel beam 4

integral, the spaces between the undulated surfaces 55 of the concrete floor boards 7b and the undulated surfaces 55 respectively confronting these surfaces 55 are filled up with concrete or cement mortar or the like. The subsequent prestress relieving method is the same as in the preceding embodiments. Thus, in this embodiment, since undulated surfaces 55 are arranged to be formed in the concrete floor boards 7b, the boards 7b are securely combined with the steel beam 4 integrally, and, when the prestress is released, the accident of slipping of the concrete floor boards on the steel beam 4 may be prevented.

In the embodiments set forth herein, in forming of composite beams as composite structural members, although steel members were employed as the foundation members and concrete members as auxiliary members, the effect is the same as when concrete is utilized as the foundation members and steel as the auxiliary members, or as when steel materials are used for both foundation members and auxiliary members, or as when concrete materials are used for both foundation members and auxiliary members. Moreover, the foundation members and auxiliary members may be members composed of compound bodies of concrete and steel.

Claims

1. A method of forming a composite stuctural member, in particular a composite girder for bridges (1) or the like, said method comprising:
-preparing concrete members (6) containing prestressing steel wire elements (8),
-preparing an elongated steel foundation member (4),
-fixedly mounting the concrete members (6) onto the foundation member (4), such that the prestressing steel elements are disposed in the axial direction of the foundation member (4) and
-releasing compressive stresses earlier generated in the concrete members (6),
characterized in that the method comprises sequentially:
-a first step of prefabricating a plurality of concrete members (6) through which sheath tubes (50) are penetrated in the axial direction of the foundation member (4),
-each of the concrete members (6) having its own compressive stress releasing means (52) as well as slots (15) or the like recesses, and
-the foundation member is prepared with dowels (24) or the like anchoring means,
-the second step of arranging the concrete members (6) widthwise onto the foundation member (4) and such that the anchoring means (24) are encompassed by the slots (15) in the concrete members,
-the third step of inserting common PC steel wires (8) through the sheath tubes (50) of a plurality of concrete members (6),
-the fourth step of applying tension to each of the PC steel wires (8),
-the fifth step of filling the slots (15) with mortar or the like connecting compound in order to fix the concrete members (6) to the foundation member (4), and
-the sixth step of at least partially release the tension in each of the PC steel wires to release the compressive stress in the concrete members acting as auxiliairy members (7) by means of the compressive stress releasing means (52).

2. A method of forming a composite structural member according to claim 1, characterized in that the first step comprising burying a sheath tube in each concrete member such that the sheath tube (50) passes through the auxiliairy member (7); passing the PC steel wire (8) through the sheath tube (50); applying to the PC steel wire (8) a tension for energizing both ends thereof away from each other and fixing and maintaining the PC steel wire (8) having both ends thereof thus energized away from each other by means of fixing means (51) and (52), and the last step comprising loosening the fixing means (51) to a desired degree so as to release the compressive stress corresponding to the desired degree from the auxiliary member (7).

3. A method of forming a composite structural member as claimed in claim 1 or 2, characterized in that the fifth step comprises placing a plurality of foundation members (4) at specified intervals; disposing across the foundation members (4) a plurality of auxiliairy members (7) each having undulated surfaces (55) formed at both ends thereof in the direction parallel to the direction of direction of the compressive stress acting in such a way that the undulated surfaces (55) at the ends of the auxiliairy members (7) confront each other on the foundation members (4); and filling the spaces between confronting undulated surfaces (55) with a bonding agent whereby the auxiliairy members (7) are fixedly disposed on the foundation members (4).

4. A method of forming a composite structural member as claimed in claim 1, 2 or 3, characterized in that concrete members (7) are utilized for the auxiliairy members (7) and steel members (4) are utilized for

the foundation members (4).

5. A method of forming a composite structural member as claimed in claim 4, characterized in that the concrete members (7) are precast concrete boards (7) and the steel members (4) are steel beams (4).

Fig. 1

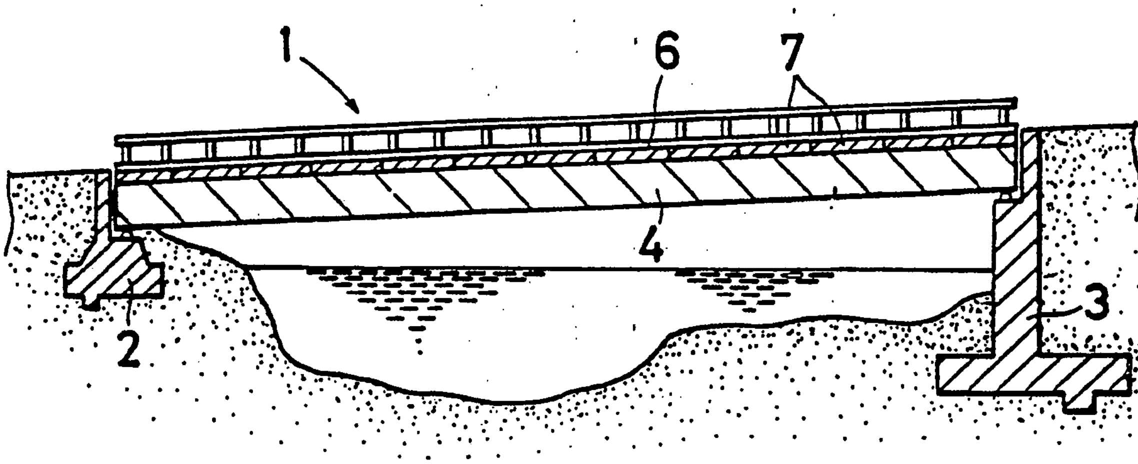

Fig. 2

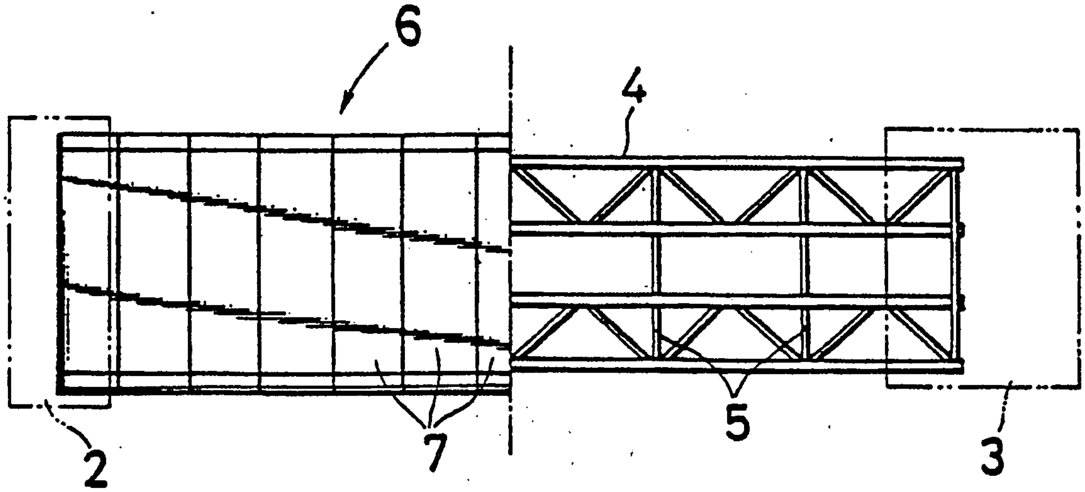

Fig. 3

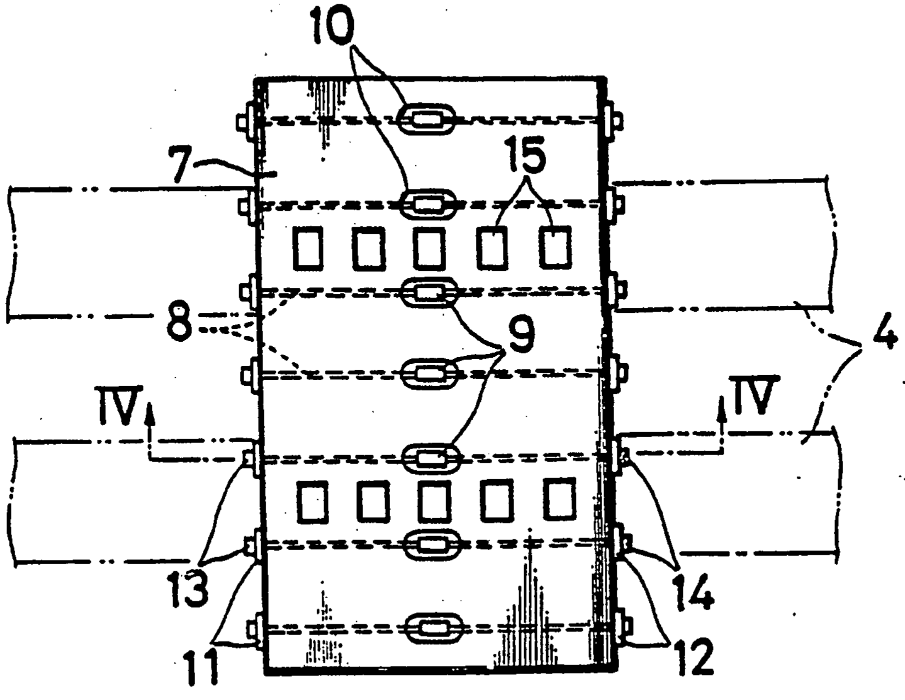

Fig. 4

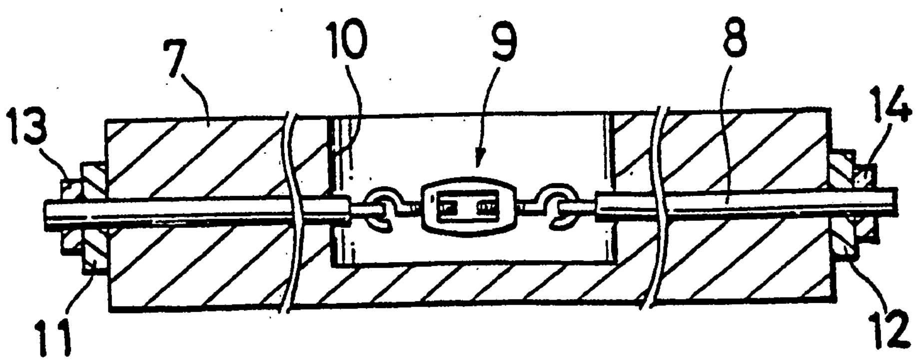

Fig. 5

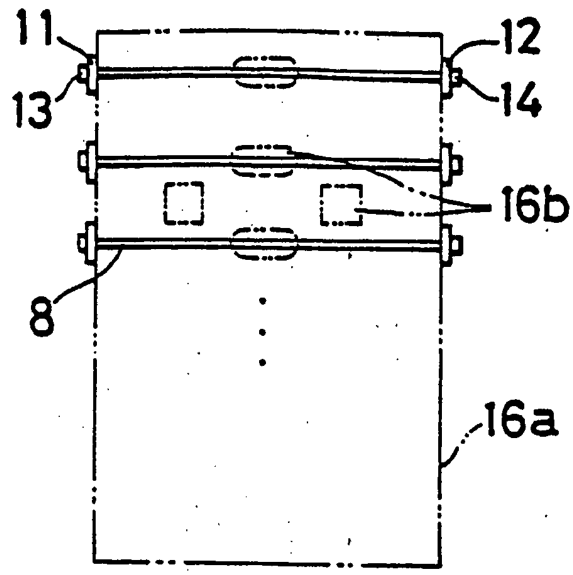

Fig. 6

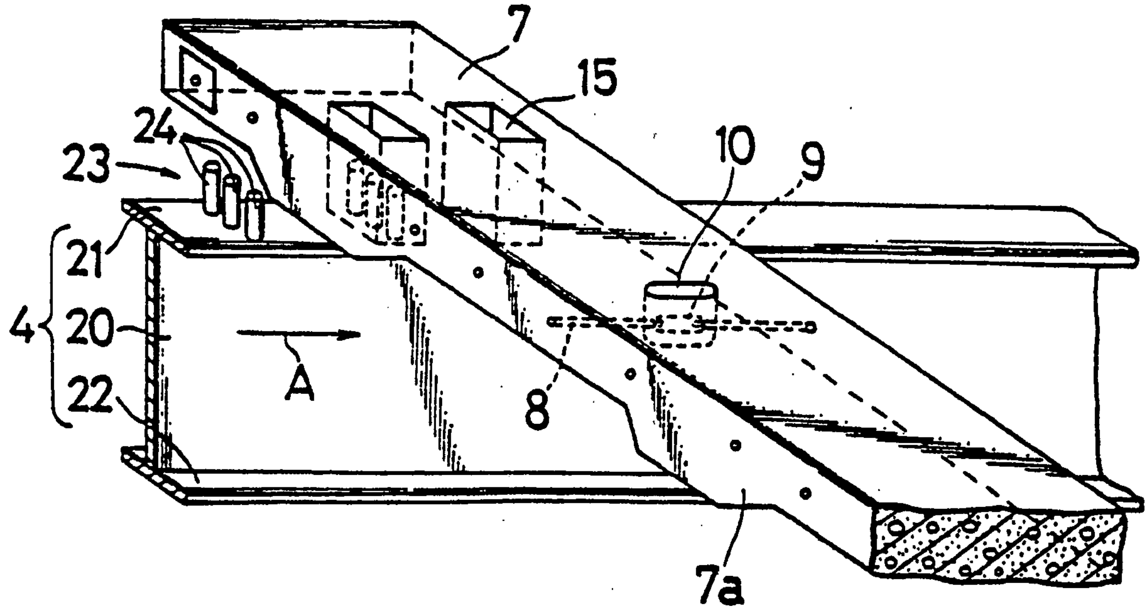

Fig. 7

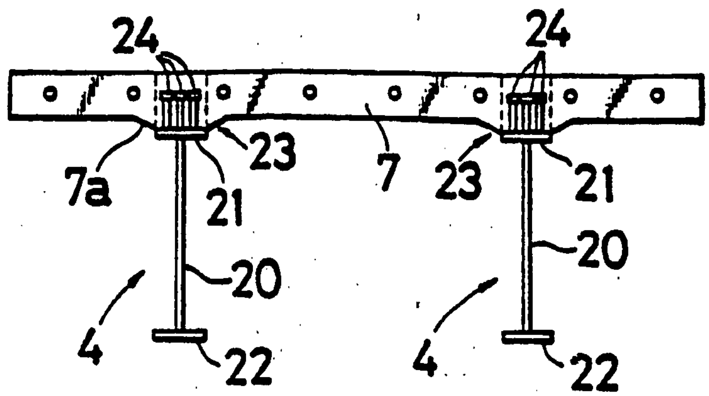

Fig. 8

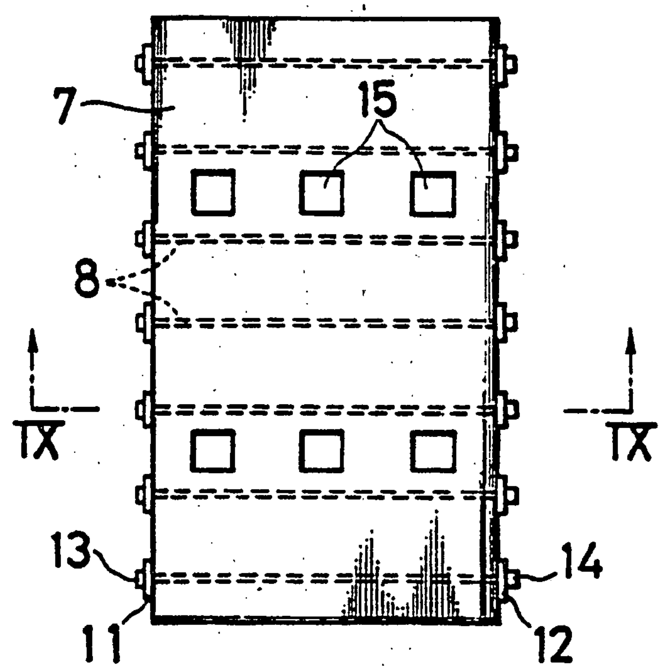

Fig. 9

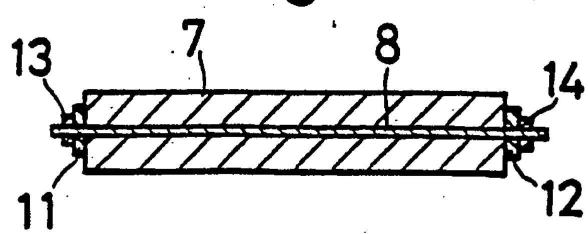

Fig. 10 (1)

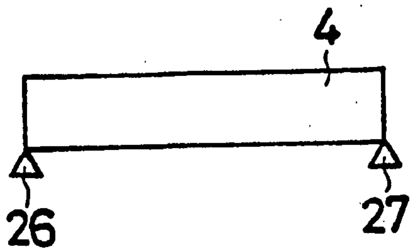

Fig. 10 (2)

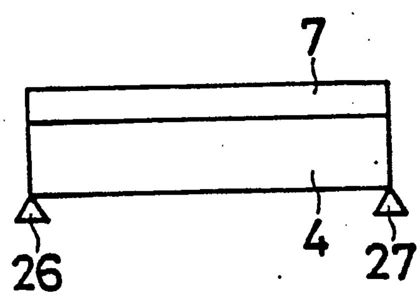

Fig. 10 (3)

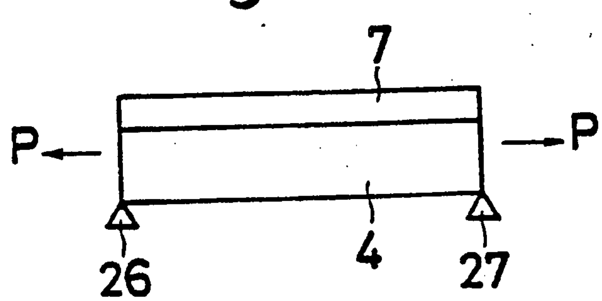

Fig. 11 (1)

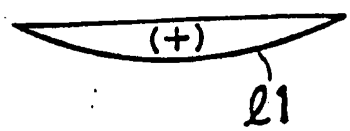

Fig. 11 (2)

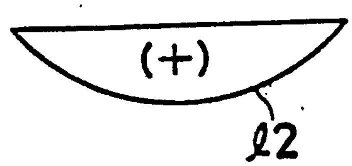

Fig. 11 (3)

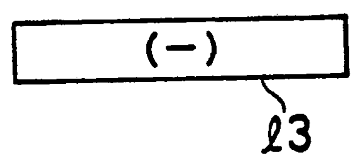

Fig. 11 (4)

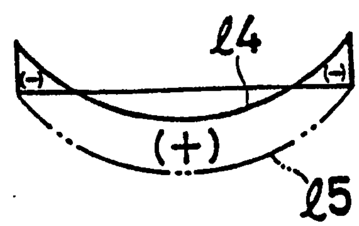

Fig. 12

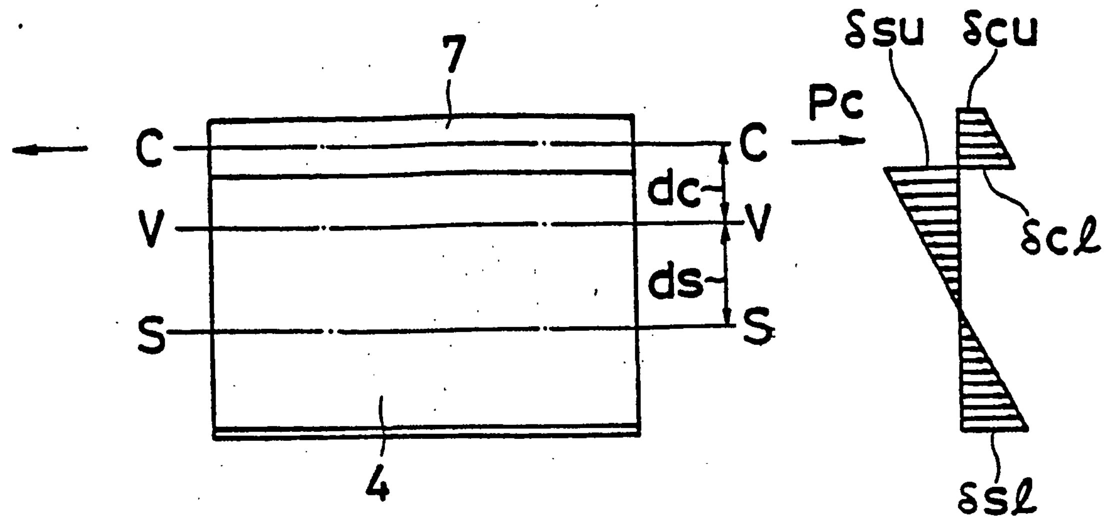

Fig. 13

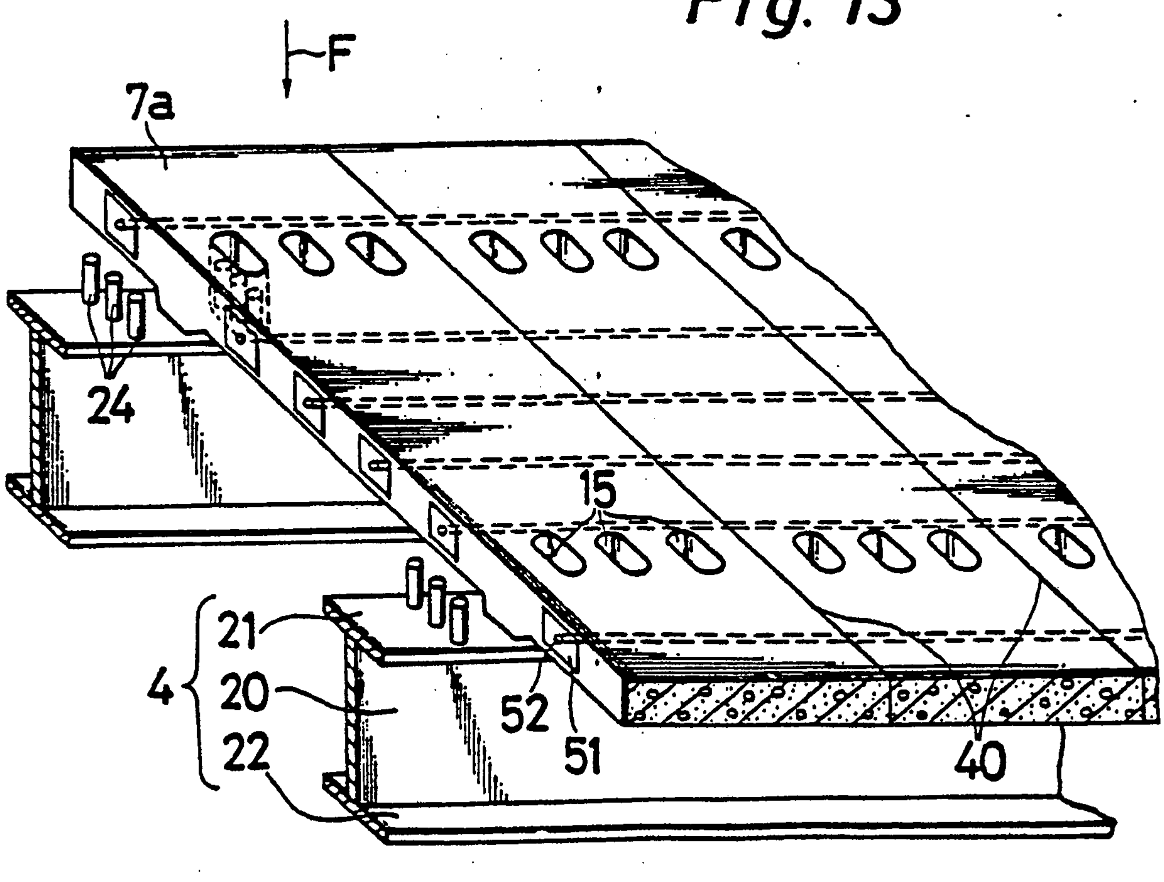

Fig. 14

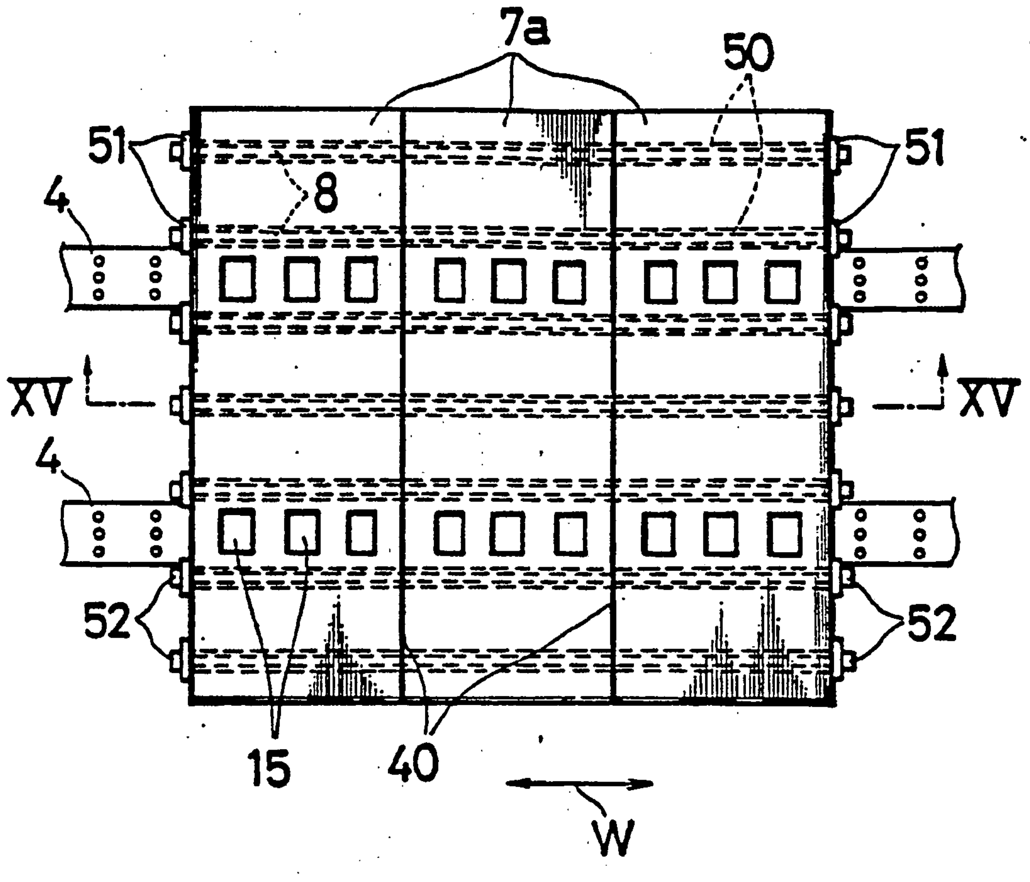

Fig. 15

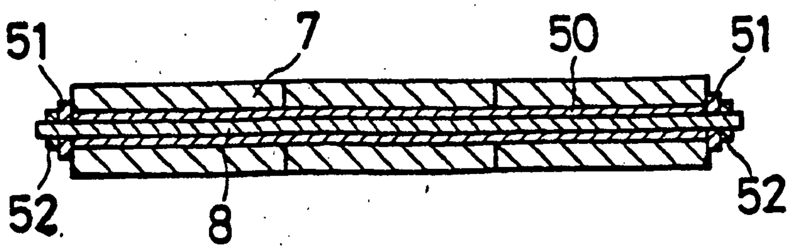

Fig. 16

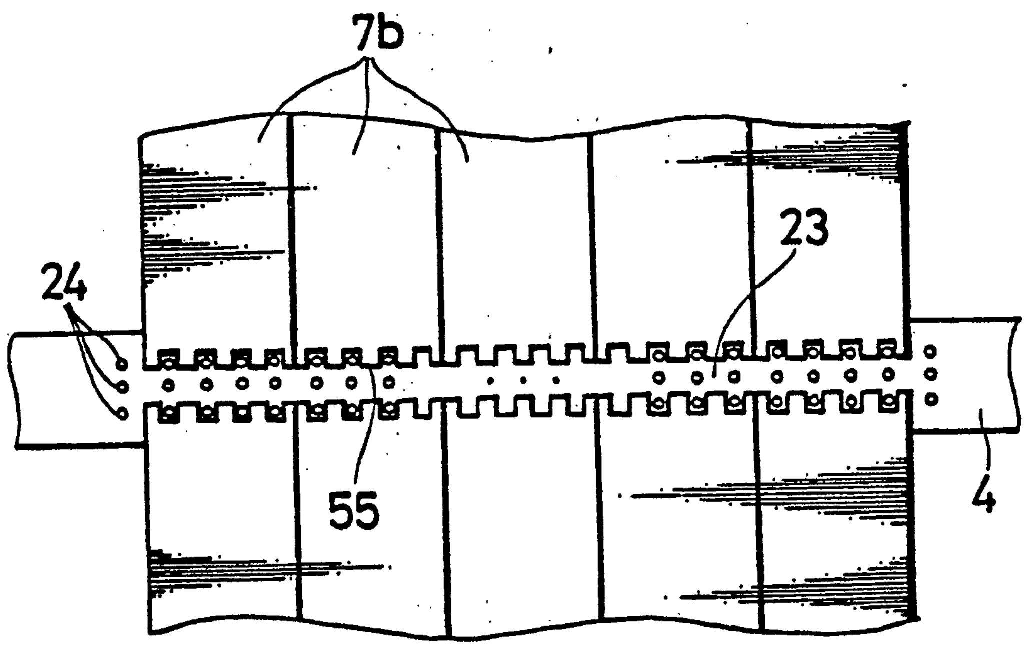

Fig. 17